

Fundamental Physics: Atom Interferometer for Gravitational Radiation

[Draft - 07/25/11]

Name of Technology (256 char)	High brightness cold atom sources	Large area atom optics	Low phase noise laser source	Extended space structures/booms
Brief description of the technology (1024)	Science objectives require high repetition rate cold atomic sources, which run at low input power and	Wavefront sensing is realized with cold atoms.	Narrow line, space-qualified, continuous-wave lasers are required for atom wave-packet manipulation in atom interferometers.	Long-baseline deployable booms are required for envisioned gravity wave sensors.
Goals and Objectives (1024)	The goal is to develop a high repetition rate (10 Hz) atomic sources capable of delivering >1e8 atoms/shot at temperatures less than 1e-6 K, in a compact (10 cm x 10 cm x 10 cm) form factor and requiring low input power (< 10 W).	Goal is to mature atom optics to a level where	Laser must achieve >1 W output power at 780 nm with a linewidth < 1 kHz.	Extend deployable booms from 100 m to 300 m.
TRL	TRL is 5.	TRL 3.	TRL is 5.	TRL is 5.
Tipping Point (100 words or less)	This is the core sub-system for any atom interferometric sensor. A three year focussed program should bring TRL to level 6.	Large area atom optics have recently been demonstrated in the laboratory in compact apparatus.	A two year development program will result in a space qualified system.	A 2 year development program will result in the required structures.
NASA capabilities (100 words)	NASA does not have capability in this area. There are currently DoD and commercial efforts pursuing this technology development.	NASA does not have a group with expertise in this area, but collaboration with university and commercial groups is feasible.	NASA has capability in this area. Suitable groups exist in industry.	NASA does not have capability in this area. Industry capability exists for smaller commercial and defense systems.
Benefit/Ranking	Ranking: iv. Such sources enable gravity wave antennas based on atom interferometry. They also support gyroscope developments for precision pointing applications, gravity gradiometers for geodesy and deep space navigation, inertial measurement units for constellation formation flying, and attitude determination for precision pointing applications.	Ranking: iv. Direct detection of gravitational radiation is one of the primary objective of relativistic astrophysics. Atom optics realized as a gravitational radiation detector could be revolutionary.	Ranking: iii. The laser source is the essential subsystem for	Ranking: iv. Large booms enable novel space structures.
NASA needs/Ranking	Ranking: iv. High flux atom sources are the core components for precision atom interferometer-based gravity wave antennas, gravity gradiometers and inertial measurement units.	Ranking: iii. Gravitational wave detection using differential accelerometry is a novel path to meeting identified astrophysics goals for study of coalescing systems.	Ranking: iii. These laser sources are required for atom interferometer-based instruments.	Ranking: iii/iv. Large deployable booms enable atom-based gravity wave antennas.
Non-NASA but aerospace needs	Ranking: ii. These sources are core components for next-generation inertial measurement units. Development for of non-NASA sources currently funded by DoD.	Ranking: ii. Large area atom optics enable accelerometer and gyroscope sensors.	Ranking: ii. Laser sources are core components for atom interferometric sensors.	Ranking: ii. Large, rigid, deployable structures may enable novel DoD systems.
Non aerospace needs	Ranking: iii. Applications to gravitational sensors for geophysics and oil/mineral exploration.	Ranking: iii. Large area atom optics enable compact gravitational sensors for geophysics and oil/mineral exploration.	Ranking: ii. Similar lasers have commercial applications in, for example, remote sensing systems.	Ranking: i. None known.
Technical Risk	Ranking: ii. Technical risk is low. Design principles have been established and validated in design and prototype testing of DoD-relevant systems.	Ranking: ii. Technical risk is moderate. The appropriate techniques have been demonstrated in ground-based laboratory systems.	Ranking: ii. Technical risk is low.	Ranking: i. Technical risk is low.
Sequencing/Timing	Ranking: iv. Should come as early as possible.	Ranking: iv. Should come as early as possible.	Ranking: iv. Should come as early as possible.	Ranking: iv. Should be concurrent with laser and atom source development. System trades depend on size of boom.
Time and Effort to achieve goal	Ranking: iii. 3 year collaboration between industry and NASA	Ranking iv. 3 year collaboration between NASA, academia and industry.	Ranking: iii. 2 year collaboration between industry and NASA	Ranking: iii. 3 year collaboration between NASA and industry.